Transplanckian Axion Monodromy !?

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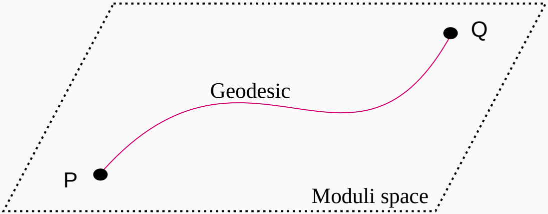
Based on: 1812.05016
in collaboration with Ginevra Buratti and Ángel Uranga.

Motivation



- SDC: $\frac{m(P)}{m(Q)} \to e^{-\alpha\Delta(P,Q)}$ as $\Delta(P,Q) \to \infty$ $(\alpha > 0)$. [Ooguri,Vafa]
- RSDC: Exponential behavior at least valid for $\Delta(P,Q) > 1$ and $\alpha \sim \mathscr{O}(1)$ (in Planck units). [Kläwer,Palti]

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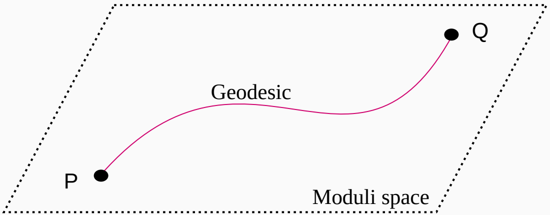

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Transplanckian field ranges are not physically attainable in Quantum Gravity ***(?)***

Claim of the paper

*KS-like throats describe **fully backreacted** axion monodromy models in which the axion **physically rolls** through transplanckian distances !!*

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- Fully backreacted
  $\longrightarrow$ Usual argument against transplanckian axion monodromy. [Baume,Palti]

- Physically rolls
  $\longrightarrow$ The axion has some spatial dependence, **not adiabatic.**

Outline

KS solution and transplanckian axion monodromy

Effective field theory analysis

Conclusion

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Type IIB Freund-Rubin $AdS_5 \times T^{1,1}$ background and the axion

1. Compactification ansatz:

$$ds_{10}^2 = \frac{r^2}{R^2}\eta_{\mu\nu}dx^\mu dx^\nu + R^2\frac{dr^2}{r^2} + R^2 ds_{T^{1,1}}^2$$

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About the compactification space...

$\rightarrow$ $T^{1,1}$ is topologically $S^2 \times S^3 \Longrightarrow \boxed{\phi = \int_{S^2} B_2}$ **Axion!**

As an axion, ϕ has a discrete shift symmetry: $\phi \sim \phi + 1$

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  [Dvali][Kaloper,Sorbo]

  Consequence of the monodromy

  $$N = N_0 + M\phi \Longrightarrow R^4 \sim g_s M\phi \rightarrow \textbf{Backreaction!}$$

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Disclaimer: This is KT solution, which is the large r limit of KS.

Transplanckian excursion of the axion

Distance in field space:

$$\Delta = \int \left(G_{\phi\phi}\right)^{1/2} \frac{d\phi}{dr} dr$$

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Together with the rolling of the axion gives

$$\boxed{\Delta \sim (\log r)^{1/2}}$$ **Transplanckian distance!**

Effective field theory analysis

Effective 5d action

In KT paper [Klebanov,Tseytlin] they use an effective 5d action to get the solution. We check that:

$$G_{\phi\phi} \sim R^{-4} \rightarrow \textbf{Transplankian distance!}$$
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BUT! $\boxed{m_{KK} \sim m_R}$

$\Longrightarrow$ This is not an EFT in the Wilsonian sense!

... Only a consistent truncation of the 10d dynamics.

Integrating out the breathing mode

Luckily, we can save the day!

$$\delta\phi \ll m_R \sim m_{KK} \rightarrow \textbf{We can integrate out R!}$$

Doing so...

$$\frac{\partial V}{\partial R} = 0 \Longrightarrow R^4 = \frac{1}{4}\left(N_0 + M\phi\right) \rightarrow \textbf{Backreaction!}$$

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✓ EFT describing the transplanckian excursion!

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However... what about the tower of states?

Main suspects: KK modes

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✓ No tower of exponentially light states!

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The low energy moduli space is 2d $\{\phi, \Phi\}$

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✓ Nothing to do with RSDC

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Thanks for your attention!

Backup slides

Hierarchy between $\{\phi, \Phi\}$ and $\{R, \phi\}$

Potential in the full 5d EFT:

$$V = e^{-8q}\left(e^{-12f} - 6e^{-2f}\right) + \frac{1}{8}M^2 e^{\Phi+4f-14q} + \frac{1}{8}\left(N_0 + M\phi\right)^2 e^{-20q}$$

For $M = 0$, both Φ and ϕ does not appear in it, while q and f are stabilized.

Considering M as a deformation of the pure $AdS_5 \times T^{1,1}$ case ($N \gg M$):

$\rightarrow$ q and f are heavy modes!

$\rightarrow$ Φ and ϕ are light!

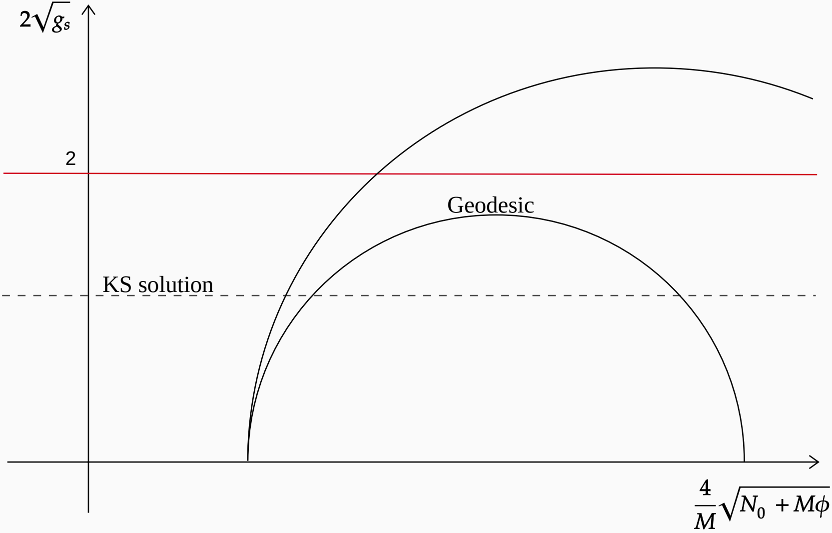
Hierarchy between $\{\phi, \Phi\}$ and $\{R, \phi\}$

But... What if $M \not< N$?

1. For large r, $\phi \gg 1$ so the axion has traveled its period many times.
2. Due to the monodromy, each time the axion cross its period $N \to N + M$.

$\Longrightarrow$ For large r we can always interpret $N \gg M$.

RSDC in $\{\phi, \Phi\}$ moduli space



RSDC in $\{\phi, \Phi\}$ moduli space

- Vertical lines:
  $\Delta \sim -\frac{1}{2} \ln (y) \sim -\frac{1}{2} \ln \left(2\sqrt{g_s}\right)$
  $\implies g_s \sim e^{-2\Delta}$
- Semicircumference:
  $\Delta \sim -\frac{1}{2} \ln (\tan (\alpha/2)) \sim -\frac{1}{2} \ln \left(\frac{y}{2R}\right) \sim -\frac{1}{2} \ln \left(\frac{\sqrt{g_s}}{R}\right)$
  $\implies g_s \sim e^{-2\Delta}$

In both cases we get a tower of stringy states becoming exponentially light satisfying the RSDC!